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VOC reduction and the Pacific Area-Wide Pest Management Program for Methyl Bromide Alternatives

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California DPR Symposium on VOC Emissions from Pesticides:

Current Research and Research Needs

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Outline

- **Part I. Background, perspective**
  - The Pacific Area-Wide Pest Management Program for Integrated MB Alternatives (PAW-MBA) and crops included
  - Fumigant use in PAW-MBA crops

- **Part II. Program specifics**
  - Strawberry, a key coastal crop
  - Almond and stone fruits (*Prunus* species), key interior crops
  - Highlights of other crops' projects related to fumigant emissions reduction

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Background

Pacific Area-Wide Pest Management Program for Integrated Methyl Bromide Alternatives (PAW-MBA)

- Five-year (2007-2011) soilborne pest management program dedicated to methyl bromide (MB) alternatives
- Administered by USDA-ARS with Core and Customer Oversight Teams, total funding up to $4.75 million for Pacific Region (focused in CA).
- Sister project (funded equally) exists in South Atlantic Region (focused in FL)
- **Overall goal: stable adoptions of MB alternatives** by industries served by Critical Use Exemptions (CUEs) for pre-plant soil use of the fumigant
- **Approach: Integrated pest management, targeted team demonstration and research**

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Background
Current status of PAW-MBA

- 10 projects initiated
  - 8 linked to crop systems covered by a MB CUE
  - 2 focused on fumigant emissions containment
- 9 in CA, 1 in OR and WA
- Projects generally crop-focused, but interconnected by interdisciplinary expertise and complimentary emphasis
- Team effort of USDA-ARS, UC, UCCE, federal and state regulatory agencies, commercial growers and nurserymen

PAW-MBA Project	Team Leader
1. Strawberry (fruit production)	S. Fennimore; UC, Davis
2. Raspberry and forest nursery	J. Pinkerton; ARS, Corvallis
3. Cut flower	J. Gerik, ARS, Parlier
4. Almond and stone fruits	G. Browne, ARS, Davis
5. Walnut	D. Kluepfel, ARS, Davis
6. Grape	D. Wang, ARS, Parlier
7. Perennial nurseries	B. Hanson, ARS, Parlier
8. Sweet potato	S. Stoddard, UCCE, Merced
9. Tarp permeability testing & emissions mgt. support, coastal crops	H. Ajwa, UC, Davis
10. Tarp permeability testing & emissions mgt. support, interior crops	S. Yates, ARS, Riversde

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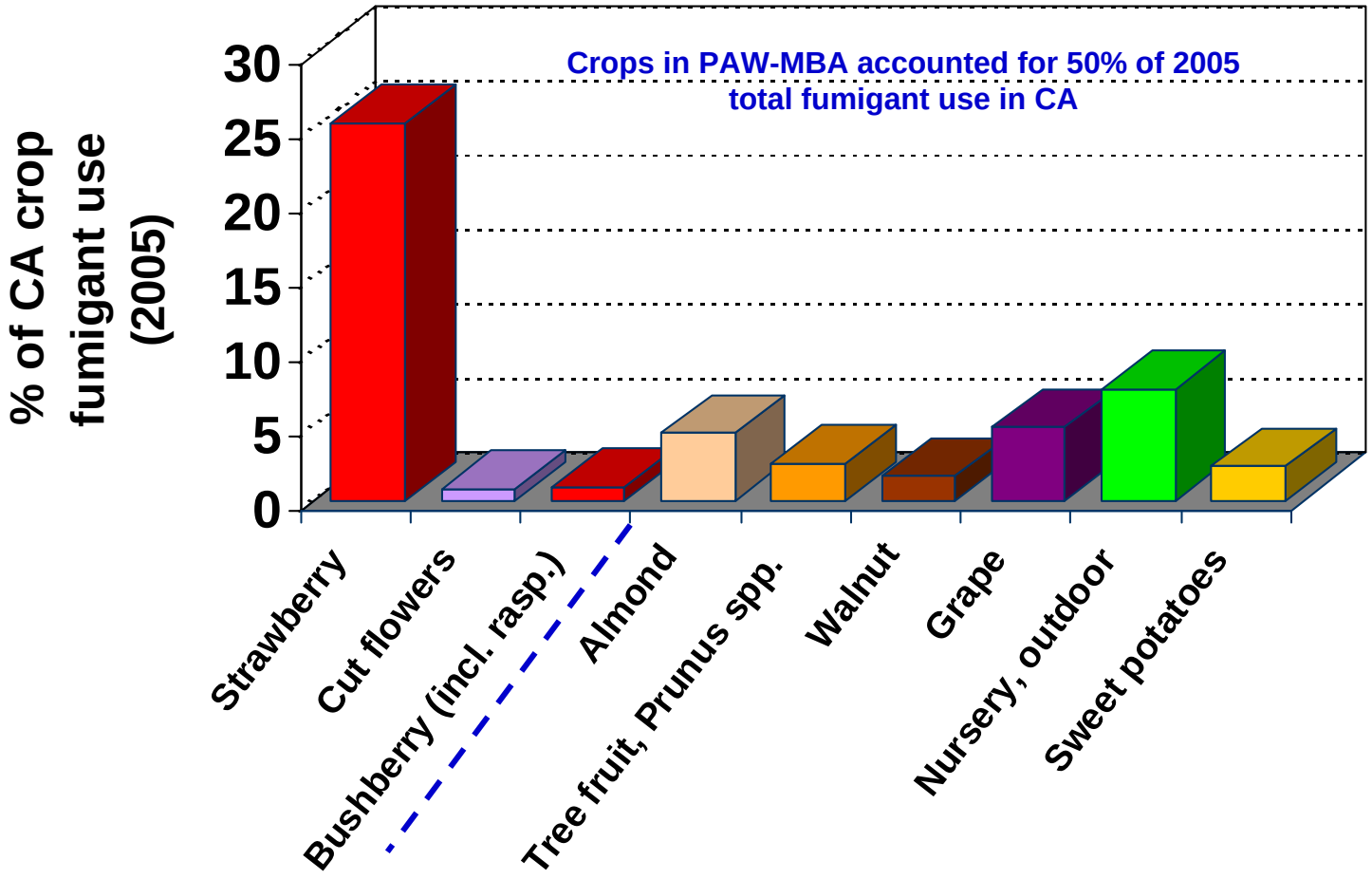
Background

Fumigant use in 2005 for CA crops in PAW-MBA

(data adapted from T. Trout)



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Background

Relative use of MB and alternative fumigants among PAW-MBA crops in CA in 2005 (data adapted from T. Trout)

Crop grouping	Percentage of total use for crop grouping			
	MB	1,3-D	CP	MS
Strawberry	37.3	18.8	40.4	3.6
Cut flowers	45.2	6.3	19.4	29.0
Bushberry	48.4	9.8	41.5	0.3
Almond	5.5	94.1	0.5	0.0
Tree fruit, *Prunus* spp.	8.8	88.7	2.5	0.0
Walnut	45.6	52.9	1.5	0.0
Grape	9.7	85.0	1.2	4.2
Nursery, outdoor	52.2	11.2	21.1	15.5
Sweet potatoes	0.1	68.9	0.1	30.9

Part II. Program specifics

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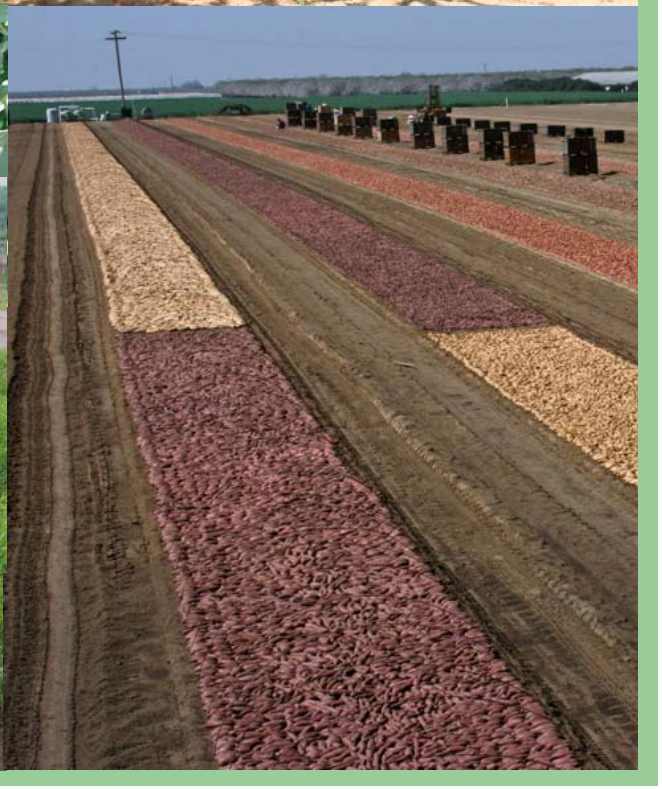

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PAW-MBA elements expected to affect or facilitate VOC management

Project sector	Program Elements [a]					
	Fumigant alternatives and use optimization [b]	Non-fumigant, chemical alternatives	Physical or biological alternatives	Genetic resistance	Diagnostic or risk mgt. support	Economic assess.
Strawberry (fruit production)	x	x	x	p	p	x
Cut flower	x				x	x
Raspberry and forest nursery	x		x		p	x
Almond and stone fruits	x		x	p	x	x
Walnut	x			x	x	x
Grape	x		x		p	x
Perennial nurseries	x				p	x
Sweet potato	x	x	x	x	p	x
Tarp perm. & emissions mgt. support, coastal crops	x					
Tarp perm. & emissions mgt. support, interior crops	x					

[a] "x" indicates current element, "p" indicates element planned for future

[b] Focused on alternative fumigants and emissions reduction through improved application methods and containment

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PAW-MBA project for strawberry

- **Factors affecting specifics of strawberry project:**
  - **Complex mix of pathogens and pests to be controlled**
  - **Limited genetic resistance available**
  - **1,3-D township caps**
  - **Increasing buffer zones**
  - **Hilly terrain not conducive to drip fumigation**
  - **Southern production region(s) in non-attainment status for air quality**
  - **Evolving regulations for fumigant emissions reduction**
- **Areas of focus in project:**
  - **Drip fumigation, low rates, containment**
  - **Growing strawberries without fumigants**
  - **(A balanced compromise– includes low-rate adaptations of semi-proven drip standards and moving ahead with high-risk experimentals)**
  - **(Optimization of shank fumigation not included at this time, an important issue for hilly terrain)**

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Fumigant-based treatments for strawberry
(low-rate adaptations of semi-proven standards, all drip applied)

Treatments*	Rate lb/acre **	Metam sodium 30 GPA	Film type
1-6. Chloropicrin (Pic)	150	+/-	VIF, SIF, HDPE
7-12. InLine (62% 1,3-D: + 33% Pic)	200	+/-	VIF, SIF, HDPE
13-18. Pic60-EC (60% Pic + 35% 1,3-D)	150	+/-	VIF, SIF, HDPE
19-24. Midas (33% iodomethane + 67% Pic)	150	+/-	VIF, SIF, HDPE
25. Methyl bromide/Pic (67% MB + 33% Pic)	300	-	HDPE
26-31. Untreated control	0	+/-	VIF, SIF, HDPE

*Fumigant emissions will be monitored for selected treatments

**Rate per treated bed area

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Non-fumigant-based treatments for strawberry, PAW-MBA **(high-risk experimentals)**

- Heat disinfestation
  - Solarization + steam
  - Solarization + hot water
  - Hot air (delivered by Cultivit) →
- Muscador (*Muscador albus*) 2,000 lb/A
- Brassica seed oil
- 2-Bromo ethanol 600 lb/A
- Acrolein 400 lb/A note – is VOC
- Furfural 600 lb/A
- Fludioxanil + Ridomil (complimentary fungicides)
- Stabilized urea 400 lb/A
- Enzone (CS_2) 200 lb/A – favorable buffer zones?
- Microbial antagonist + composts in a systems approach

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PAW-MBA Objectives, strawberry

- ✓ **Evaluate reduced rates of alternative fumigants applied by drip fumigation under VIF, SIF**
- ✓ **Strawberry production without fumigants**
- **On farm demonstrations of drip fumigation, barrier films**
- **Measurement of fumigant retention, selected treatments**
- **Technology transfer/outreach**

<u>Related areas of concern / remaining needs</u>:

- **Emissions reduction for shank fumigation on hilly terrain**
- **Ambient emissions monitoring**
- **Continuing development of genetic resistance / tolerance**

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PAW-MBA project for almond and stone fruits

- **These crops are mostly transitioned to 1,3-D from MB, but must deal with instability and lack of efficacy of the transition:**
  - **Instability:** 1,3-D township caps, VOC / Clean Air Act, fumigant reviews, use restrictions
  - **Lack of efficacy:** 1,3-D not effective for PRD, soil diffusion limitations
- **Key biological replant problems of concern:**
  - **Plant parasitic nematodes** approx. 35% of almond and fresh stone fruit acreage, 60% of cling peach acreage infested (McKenry)
  - **Prunus replant disease**: caused by soilborne microbial complex; incidence nearly universal in *Prunus* planted after *Prunus*; severity varies greatly (Browne)
  - **Aggressive pathogens** (*Phytophthora, Verticillium, Armillaria*)
- **Opportunities for performance enhancement, emissions reduction:**
  - **Matching fumigants and application variables (rate, applic. method, area treated) to replant situation (soil type, crop history, predicted risk).** (Need database, predictive tools). Example: PRD vs. parasitic nematodes
  - **Spot treatments have potential for long term efficacy and emissions reduction** (need application technology)
  - **Increased reliance on cultural management**

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PAW-MBA Objectives, almond and stone fruits

1. **Develop and demonstrate optimized use of fumigant alternatives to MB**
   a. **Focus on minimum rates and proportions of treated area**
   b. **Focus on application methods that minimize non-target fumigant emissions**
2. **Improve and demonstrate IPM strategies for managing replant problems**
   a. **Focus on non-chemical strategies**
   b. **Focus on site-specific risk-based guidelines**
3. **Provide comprehensive economic assessments of alternative replant management strategies**
4. **Conduct multi-faceted educational outreach to foster grower utilization of program findings**

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*Fumigant-based trials, almond and stone fruits, optimizing fumigant choice, rates, % treated area)**

Trt.	Fumigant, rate per treated area	Treated area (% of total)	Fumigant per orch. acre (lbs)
1	Control	None	0
2	Methyl bromide, 400 lb/a	11-ft row strip (50%)	200
3	Telone II, 340 lb/a	11-ft row strip (50%)	170
4	Chloropicrin (CP), 400 lb/a	11-ft row strip (50%)	200
5	CP, 300 lb/a	11-ft row strip (50%)	150
6	CP, 200 lb/a	11-ft row strip (50%)	100
7	CP, 400 lb/a	5-ft (w) x 8-ft (l) tree site (10%)	40
8	Midas (iodomethane:CP. 50:50), 300 lb/a	11-ft row strip (50%)	150
9	Telone C35, 540 lb/ac	Broadcast (100%)	540
10	Telone C35,540 lb/ac	11-ft row strip (50%)	270
11	Telone C35, 540 lb/ac	5-ft (w) x 8-ft (l) tree site (10%)	54
12	Pic-clor 60, 400 lb/ac	11-ft row strip (50%)	200

**Spot treatments (7 and 11) will be applied with prototype GPS-controlled shank fumigation rig; all others with standard shank rig; GPS system refinements being developed*

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Previous responses to pre-plant fumigation with CP-containing fumigants, 2003 almond replant trial Madera Co. (w/ Lampinen, Holtz, Schneider)

Fumigant, rate	Plot area treated	Mulch system	Trunk circ. incr. (% of control)		2006 Gross Nut Yield (kg/tree)
			2004	2005	
Control	None	None	0	0	4.1
Control	None	VIF	-6	-2	3.0
MB, 400 lb/a	Br. (100%)	None	4	3	5.1
MB, 400 lb/a	R. strip (38%)	None	-4	1	4.6
MB, 400 lb/a	R. strip (38%)	VIF	-2	-3	4.5
MB, 1 lb / tree site	*Tree site*	*None*	*0*	*0*	*5.1*
Telone II, 340 lb/a	Br. (100%)	None	11	9	5.7
Telone II, 340 lb/a	R. strip (38%)	None	6	4	5.0
Telone II, 340 lb/a	R. strip (38%)	VIF	0	0	5.0
Telone II, 1 lb / tree site	*Tree site*	*None*	*-11*	*-7*	*4.6*
CP 400 lb/a	Br. (100%)	None	17	12	5.9*
CP 400 lb/a	R. strip (38%)	None	30	19	6.4*
CP 400 lb/a	R. strip (38%)	VIF	28	17	7.1*
CP, 1 lb / tree site	*Tree site*	*None*	*-13*	*0*	*4.4*
IM:CP (50:50), 400 lb/a	Br. (100%)	None	29	18	7.2*
IM:CP (50:50), 400 lb/a	R. strip (38%)	None	19	19	6.4*
Telone C35, 535 lb/a	Br. (100%)	None	16	17	7.0*
Telone C35, 535 lb/a	R. strip (38%)	None	27	16	6.7*

Yield increases:

+ 45-72% of ctl

+ 56-76% of ctl

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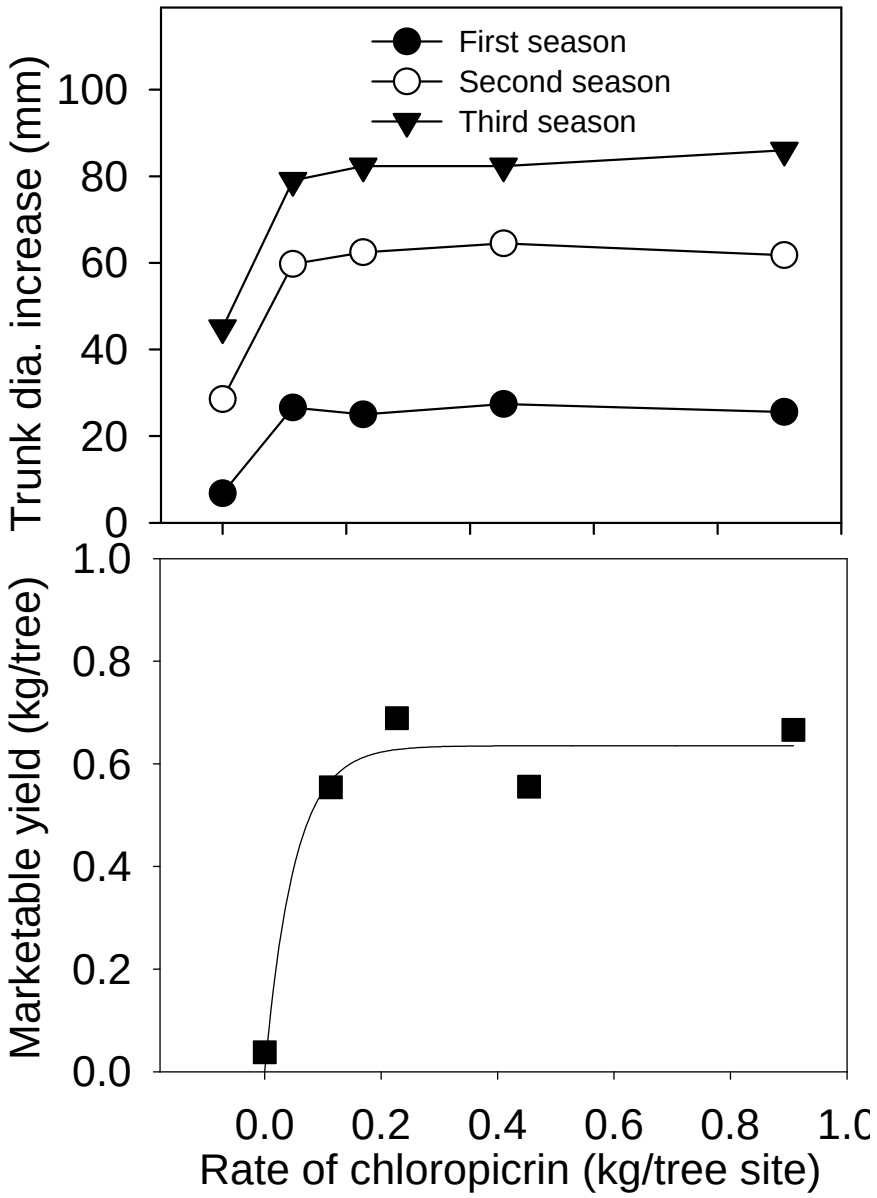
Demonstrated potential of spot treatments for tree sites, almond

- **Low rates (25 to 50 lb/a) of tree-site spot treatments with chloropicrin were effective for severe PRD in Butte County**
- **More long-term examinations of spot treatments needed**
- **Safe, efficient methods of spot application targeted**



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Development of spot fumigation technology is part of PAW-MBA

GPS-controlled shank spot application of fumigant in fall 2006 with prototype system developed by Upadhyaya et al. in cooperation with TriCal, Inc. Work continuing with Upadhyaya and Giles.

Drip spot application of fumigant in fall 2005 in collaboration with Tom Trout

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Evaluating and integrating spot treatments, part of PAW-MBA for almond and stone fruits

Trt.	Fumigant, application method, rate per treated area	Treated area (% of total)	Fumigant per orchard acre (lbs)	Sudan grass rotation
1,2	Control	None	0	+/-
3,4	MB, shank, 350 lb/a	Row strip (50%)	175	+/-
5,6	Telone C35, shank, 540 lb/a	Row strip (50%)	270	+/-*
7,8	Telone C35, shank, 540 lb/a	5-ft (w) x 8-ft (l) tree site (14%)**	49	+/-*
9,10	Chloropicrin, shank, 400 lb/a	5-ft (w) x 8-ft (l) tree site (14%)	35	+/-
11,12	Inline, drip, 540 lb/a	5-ft-dia spot drip at tree site (7%)	39	+/-*

***Trts. will be monitored for peak and total fumigant emissions by Wang, Gao, and Yates (flux-based method)**

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Non-chemical support for IPM, almond and stone fruits:
Single-season crop rotation with sudan grass suppressed PRD in microplots; will be tested in orchards in PAW-MBA

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Non-chemical support for IPM:

Interaction of irrigation intensity with pre-plant fumigation will be examined in almond replanted after almond in PAW-MBA, Lampinen et al.

Pre-plant fumigation treatment	Irrigation intensity (% of estimated evapotranspiration) and Treatment number			
	70 % ET	85 % ET	100% ET	130 % ET
Non-fumigated control	1	2	3	4
Pic-clor 60, 400 lb/a (8-ft row strip)	5	6	7	8

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Selected highlights of other PAW-MBA project plans related to fumigant emissions reduction and VOC management

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Cut flower project, Gerik, Klose, et al.

Shank trials

Treatments	Rate lb/A	Plastic type
Chloropicrin (Pic)	150	VIF
Telone C35 (62% 1,3-D + 35% Pic)	200	VIF
Methyl bromide/Pic (67% MB + 33% Pic)	350	HDPE
Midas (33% iodomethane + 67% Pic)	150	VIF
Untreated Control	0	VIF/HDPE

Drip trials

Treatments	Rate lb/A	Metam sodium gal/A	Plastic type
Chloropicrin (Pic)	150	26	VIF/HDPE
InLine (62% 1,3-D + 33% Pic)	200	26	VIF/HDPE
Pic60 EC (60% Pic + 35% 1,3-D)	150	26	VIF/HDPE
Midas (33% iodomethane + 67% Pic)	150	26	VIF/HDPE
Methyl bromide/Pic (50% MB + 50% Pic)	150	26	VIF/HDPE
Untreated Control	0	26	VIF/HDPE

Also will include greenhouse demonstrations of drip-applied 1,3-D:CP as alternative to MB hot gas

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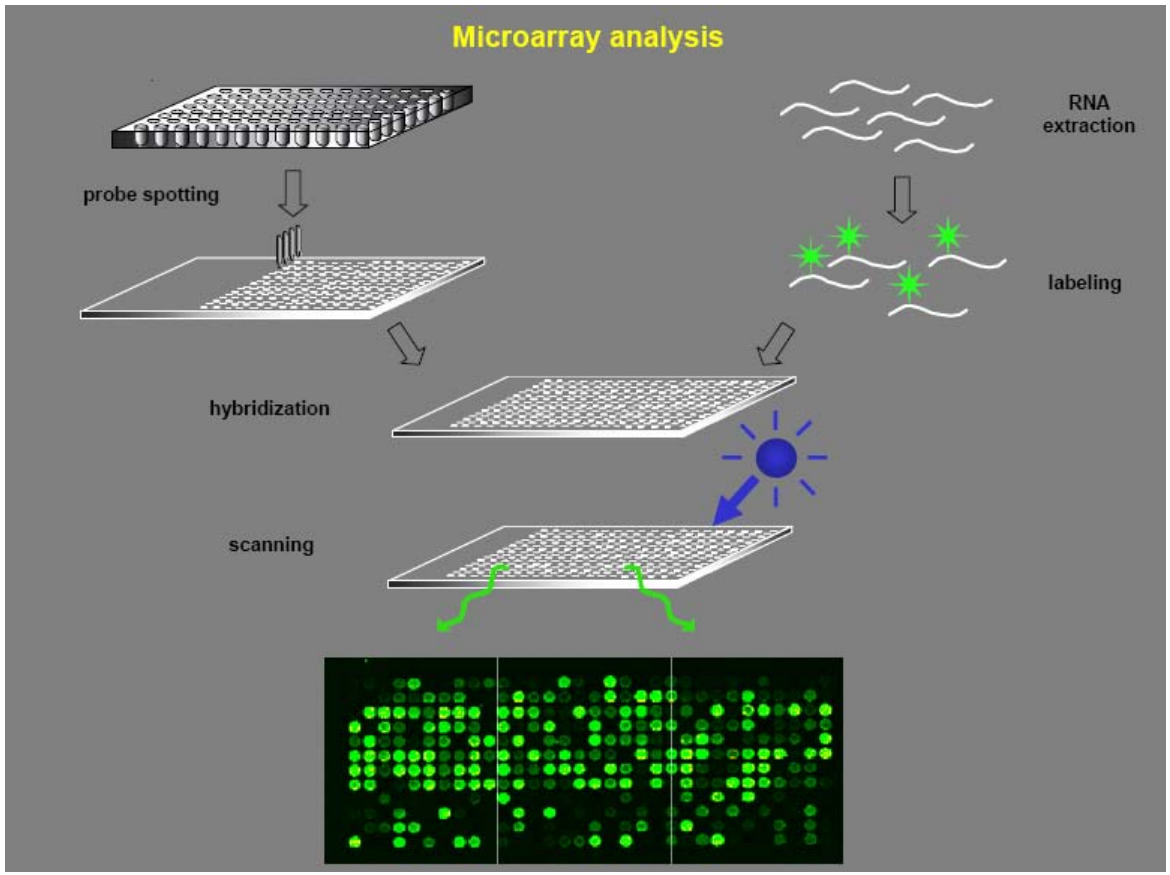
Walnut project, Kluepfel et al.

1. **Improved pre plant fumigation strategies for walnut orchards and their economic assessment**
2. **Microarray-based microbial detection technologies for soilborne pathogens**



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Grape project, Wang et al.

Major focus on broadcast fumigation issues, vineyard setting:

- Emissions and efficacy assessment
- Shank vs. drip effects
- Rate effects
- HDPE vs. VIF mulch effects

Non-chemical support for IPM:

- Will examine short term crop rotation with *Brassica* sp.

Treatment list; trts. 4-7 will be monitored for fumigant emissions

Treatment	Rate of fumigant (lb/ac)	Film mulch
1. Non-treated control	0	None
2. Fall cover crop (Brassica. sp.)	0	None
3. Shank-injected MB	400	HDPE
4. Shank-injected Telone C35	544	None
5. Shank-injected Telone C35	272	None
6. Shank-injected Telone C35	272	VIF
7. Drip-applied Inline	272	VIF

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Perennial nursery project, Hanson et al.

Major focus on broadcast fumigation issues, nursery setting:

- Emissions and efficacy assessment
- Effects of fumigant combinations and dual "flipping" treatments
- Containment (HDPE vs. VIF vs. water)
- Shank improvement

Treatment list; those in blue will be monitored for fumigant emissions

Treatment		Fumigant rate (lb/ac)	Surface treatment	Shank system
1	Untreated	None	None	None
2	Methyl bromide	300	HDPE tarp	Noble plow
3[a]	Telone II	332	HDPE tarp	Standard
4[a]	Telone II	332	HDPE tarp	Winged
5[a]	Telone II fb Telone II	285 fb 190	Flipped, retreated	Standard
6[a]	Telone II fb Telone II	285 fb 190	Flipped, retreated	Winged
7[a]	Telone II fb Vapam	332 fb 200	Vapam cap	Standard
8[a]	Telone II fb Vapam	332 lb fb 200	Vapam cap	Winged
9[a]	Telone II	332	Water seal	Standard
10	Telone II	332	Water seal	Winged
11[a]	Telone II	332	VIF	Standard
12	Telone II	332	VIF	Winged

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Sweet potato hotbed project, Stoddard et al.

Major focus on IPM in unique vegetable crop propagation setting:

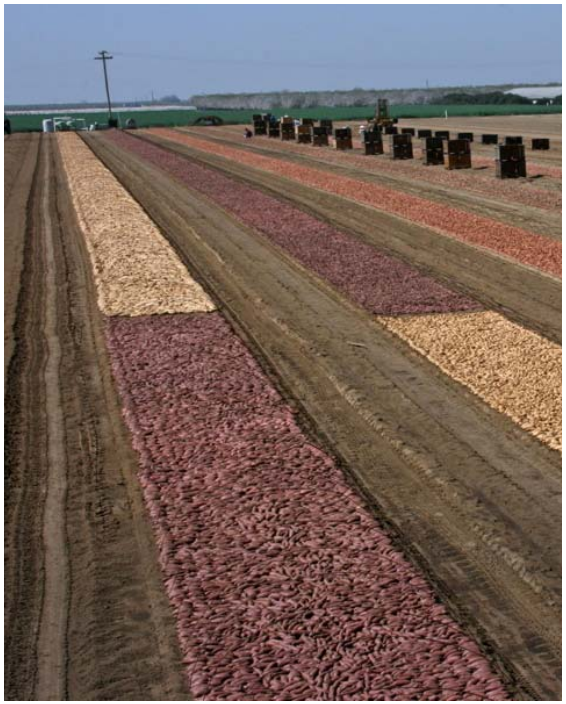
- Crop performance assessment
- Integrated combinations of fumigant, non-fumigant chemical, cultural, and genetic treatments examined

Main plot treatments:

1. **Non-trt. control**
2. **MeBr/Pic, tarped, 57/43, 350 lb/ac**
3. **Telone + Pic, Tarped**
4. **Vapam, flood, 75 gpa**
5. **Pic alone, tarped, 150 lbs/A**
6. **Flat solarization**

Sub plot treatments:

1. **Non-trt. control**
2. **Devrinol herbicide, pre**
3. **Valor herbicide, Pre**
4. **Botran fungicide**
5. **Merteck fungicide**
6. **Variety: Resistant and susceptible**



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Film permeability testing and emissions management support (2 projects), Ajwa et al. (coastal emphasis) and Yates et al. (interior emphasis)

- Will address need for comprehensive evaluations of diverse plastic films' permeability to fumigants
- Will evaluate effects of VIF gluing methods on film permeability
- Will assess impact of field-laying practices on film permeability
- Will assist in emissions monitoring, coastal and interior projects

Virtually Impermeable Film (VIF)

PE

Polyamide

PE

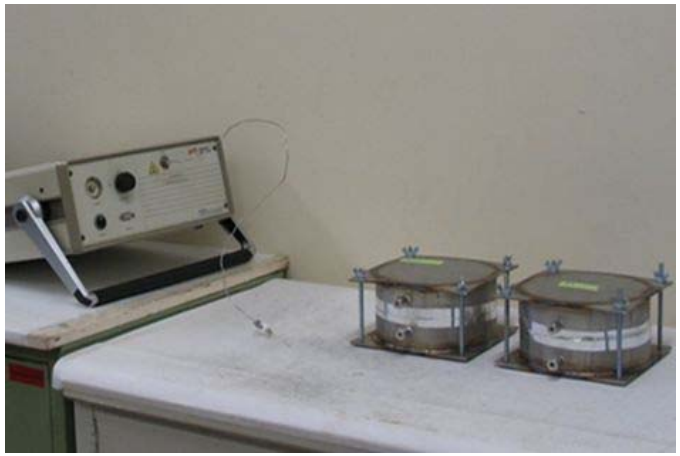
Semi-Impermeable Film

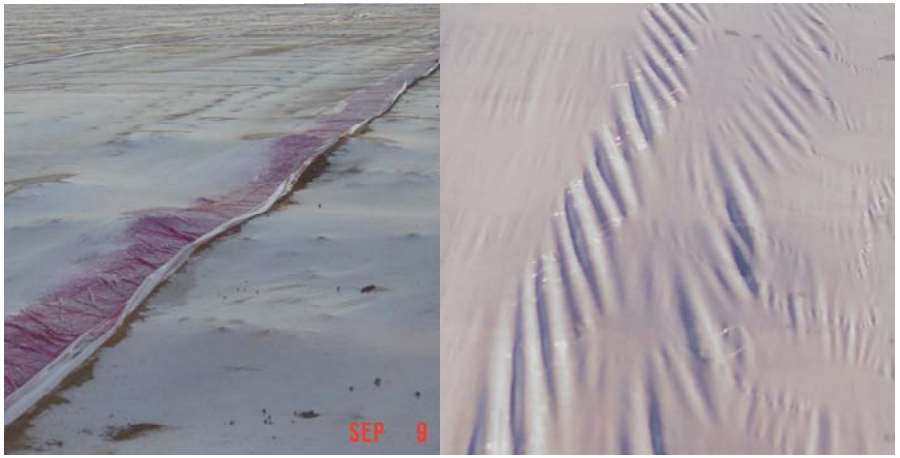
LDPE

Semi-impermeable Polymer PE

LDPE

Metalized Film





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Additional products, all crop-based PAW-MBA projects:

- **A database that will support IPM by documenting trial site characteristics (i.e., physical, chemical, biological) and crop responses to treatments**
- **Economic assessments of treatments that will support IPM**
- **Economical management guidelines**

Thank you!